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(58) Field of search
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(54) Temperature control of light-emitting devices

(57) The temperature of the junction of a light-emitting semiconductor junction device 1 (e.g. an LED or laser diode) is measured by using the forward bias voltage/current characteristic of the device to provide an indication of the junction temperature and then controlling the temperature of the junction to a predetermined value in order to stabilise the output wavelength of the device. As shown the forward bias current of the device is measured by ammeter 3 and the forward voltage is measured by voltmeter 4. A signal processor 5 calculates the junction temperature and controls a temperature controller 6 to heat or cool the device. Alternatively the signal processor 5 may control the current source 2 and thereby vary the temperature of the junction by direct heating.

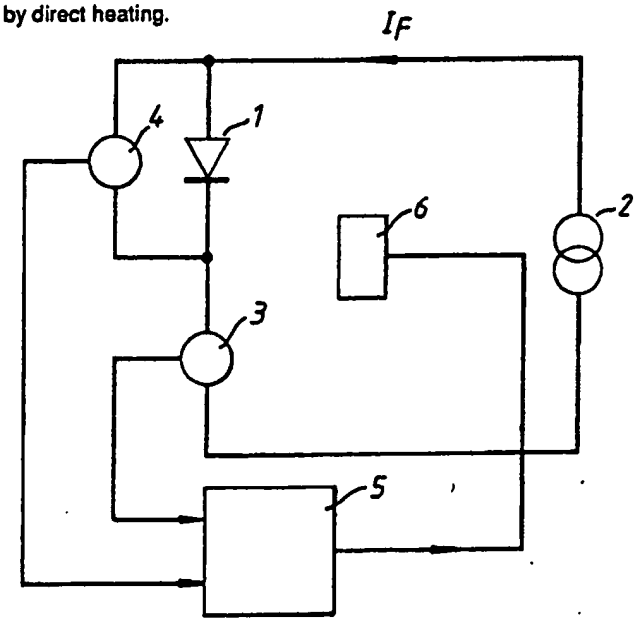

Fig.1.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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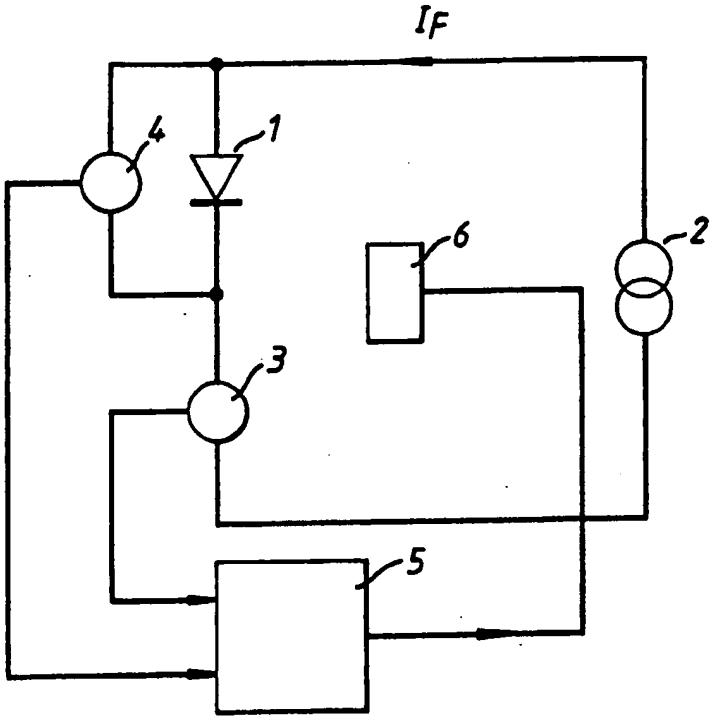

Fig.1.

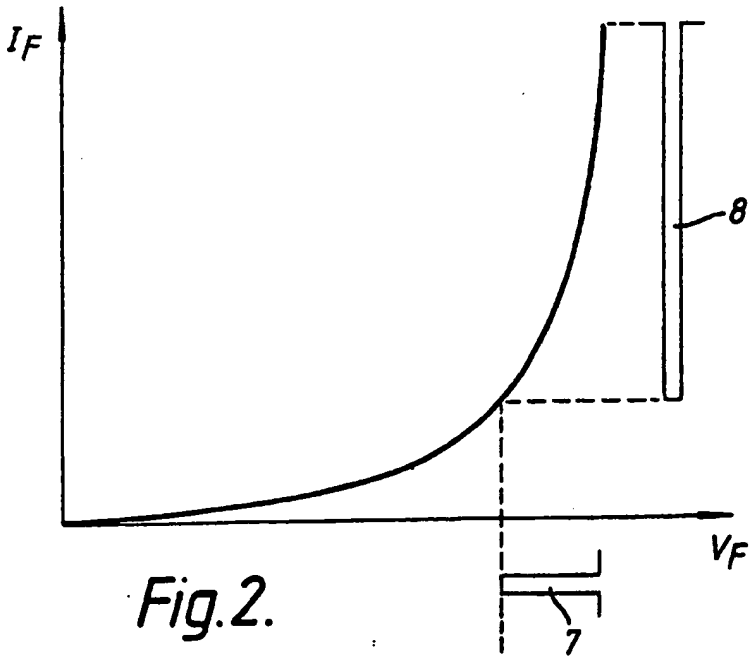

Fig.2.

IMPROVEMENTS RELATING TO TEMPERATURE CONTROL ARRANGEMENTS FOR LIGHT EMITTING SEMICONDUCTOR JUNCTION DEVICES.

This invention relates to temperature control arrangements for light emitting semiconductor junction devices (eg. light- emitting or laser diodes). Such temperature control arrangements may serve to stabilise the output wavelengths of the light -emitting semiconductor junction devices.

It is well known to control the temperature of a semiconductor junction device light source by the resistive heating and cooling of the light source to a controlled temperature, or by using a Peltier effect heater/cooler unit to maintain the light source at a pre-set controlled temperature. With these known arrangements, the information on the temperature of the light source concerned is derived from a discrete temperature sensor mounted in intimate thermal contact with the structure embodying the light source. The consequent disadvantage of such arrangements is that the temperature information derived appertains only to the temperature of the device packaging or housing, whereas in many applications (eg. optical sensing systems), in which it is desired to keep the output wavelength of the light source device stable, it is necessary to measure and control the temperature of the actual internal semiconductor junction of the device, in order to ensure the desired wavelength stability.

According to the present invention, therefore, the temperature of the junction of a light - emitting semiconductor -junction device such as a light - emitting diode (LED) or a laser diode (LD) is achieved

by using the forward bias voltage/current characteristic of the device to provide an indication of the junction temperature and then controlling the temperature of the desired region, accordingly, to a predetermined value in order to stabilise the output wavelength of the device.

In carrying out the present invention, the forward current of the junction device may be pre-set to a predetermined fixed level and the temperature of the junction device maintained at a particular value, by means of a separate heating or heating/cooling arrangement, controlled from the forward voltage of the light-emitting device.

Alternatively, the forward current of the junction device may itself be variably controlled in dependence upon the measured forward voltage (which in turn, depends on the junction temperature) in order effectively to heat or cool the junction of the device.

By way of example, the present invention will now be described with reference to the accompanying drawings in which:-

Figure 1 is a schematic diagram of a temperature controlling arrangement for a light emitting semiconductor junction device according to the invention; and,

Figure 2 is a diagram showing the exponential voltage/current characteristic of the semiconductor junction device of Figure 1.

Referring to Figure 1 of the drawings a semiconductor light-emitting diode or laser diode 1 is connected to be driven by a forward bias current I_F derived from a current source, 2. The current I_F is measured by means of an ammeter 3. (or equivalent

current-sensing electronic circuit) connected in series with the diode 1 and the forward voltage across the diode is measured by means of a voltmeter 4 (or equivalent voltage sensing electronic circuit). Electrical outputs from the ammeter 3 and the voltmeter 4 are representative of the forward current and voltage, respectively, and are applied to a signal processor 5 which provides an electrical output for controlling the temperature of the diode 1.

It may here be mentioned that the forward current I_F in an ideal semiconductor junction diode is given to a close approximation by:-

$$I_F = I_0 e^{qV_F/KT}$$

where I_0 is a constant, q is the electronic charge, V_F is the forward voltage, K is the gas constant (Boltzmann's constant) and T is the absolute temperature which needs to be controlled for wavelength stabilisation purposes. Thus, if the forward voltage and current of the diode 1 are measured and the constant current I_0 is known (this need not be known very accurately in practice in view of the exponential nature of the above equation) then the temperature T may be deduced.

Thus, with the light-emitting diode or laser diode 1 connected in the circuit, as shown, where it is driven with a forward bias current I_F which may be either pre-set to a predetermined known value by providing a constant current source or which may, alternatively, be measured by means of an ammeter 4, the value of the current I_F will be known or determined. Thus, if the voltage

across the diode 1 is also measured by means of the voltmeter 4 then the temperature of the diode 1 junction region can be calculated by the signal processor 5 from the voltage/current characteristic of the diode, as shown in Figure 2 of the drawings, and the result used as a correction input to a temperature controller 6 which heats or cools the diode to the required temperature and maintains the temperature at or near to the desired level. Alternatively, the output from the signal processor 5 may be used to control the current source 2 in order to vary the current I_F and thereby vary the temperature of the junction by direct heating thereof without the need for discrete heating elements. One slight problem which may occur is that the above formula tends to become inaccurate at high bias current levels due to the voltage drop across internal parasitic resistances, such as contact resistances and series- spreading resistances. A solution to this is to apply appropriately a transient voltage pulse 7 or current pulse 8 (Figure 2) to the device 1, in order to drive the current I_F temporarily to a low value close to the knee of the voltage/current characteristic of the diode 1. At this point, the parasitic resistive voltage drops referred to are lower and the device more closely follows the equation or formula above. The calculation by the processor means 5 may, of course, be performed by a wide variety of simple analogue or digital electronic circuits of which a wide variety of types are available with configurations well known to those skilled in the art.

CLAIMS:-

1. A temperature controlling arrangement for controlling the temperature of a light emitting semiconductor junction device, in which the instantaneous temperature of the junction is calculated by processor means from the forward bias voltage/current characteristic of the device and in which the processor means provides an electrical output for maintaining the temperature at a desired value.

2. A temperature controlling arrangement as claimed in Claim 1, in which the forward biasing current of the device is derived from a constant current source and the electrical output from the processor means controls discrete heating or heating/cooling means for heating or heating/cooling the junction device.

3. A temperature controlling arrangement as claimed in Claim 1, in which the electrical output from the processor means controls the value of the forward bias current which directly controls the temperature of the junction of the device by the self-heating effects of the current through the device.

4. A temperature controlling arrangement as claimed in any preceding claim, in which a transient voltage or current pulse is applied to the junction device to drive the biasing current temporarily to a low value in order to reduce the value of voltage drops across parasitic resistive elements within the device or its packaging.

5. A temperature controlling arrangement as claimed in any preceding claim, in which the biasing current is measured by means of an ammeter and voltage is measured by means of a volt- meter

and representative respective outputs therefrom are fed to the processor means for the calculation of the junction temperature.

6. A temperature controlling arrangement substantially as hereinbefore described and as shown in the accompanying drawings.

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